

REMARKS

The Office Action dated August 7, 2007 has been received and carefully studied.

A Request for Continued Examination is submitted herewith.

The Examiner maintains the rejection of claims 1-2 and 4-5 and 23 under 35 U.S.C. §103(a) as being unpatentable over Brown, et al., U.S. Patent No. 4,990,248. With respect to Applicant's previous arguments, the Examiner now states that the word "cartridge" does not impart any structural limitation to the claims.

The rejection is respectfully traversed.

The term "cartridge" is a term of art and has structural components well known to those skilled in the art, including a core, two end caps, a filter and an outer cage. Submitted herewith to demonstrate the pervasive use of the term "cartridge" as including these components are several literature references and U.S. Patents. Specifically, Exhibit A attached hereto are excerpts from Brock, Thomas D., "Membrane filtration: A User's Guide and Reference Manual", pages 43-44 and 101-107 (1983). This Manual discusses the formation of filter cartridges, wherein large membrane sheets are folded in a pleated fashion and then wrapped around the central plastic

cartridge core, followed by the addition of end caps which seal the membrane and the core. The cartridge is then housed in an outer cage or housing. See also U.S. Patent Nos. 4,878,930 and 5,207,812 attached hereto as Exhibits B and C. Numerous other patents exist that similarly show such cartridges.

Moreover, the instant specification itself indicates that "cartridges" are "known in the art"; see paragraph [0005] of the published application. See also paragraph [0069]:

"... the reverse osmosis cartridge 51 is of the kind including a cylindrical enclosure 52 and a hollow perforated central tube 53 concentric therewith."

Accordingly, the Examiner's conclusion that the word "cartridge" does not impart any structural limitation to the claim is not only factually incorrect, but is legally incorrect as well. It is well settled that all words in a claim must be considered in judging the patentability of a claim against the prior art. *In re Wilson*, 424 F.2d 1382, 165 USPQ 494 (CCPA 1970).

Applicants again respectfully submit that in articulating the various elements of Brown that allegedly meet the limitations of the instant claims, the Examiner

has improperly combined disclosure of Brown that relate to very different embodiments. Specifically, the Examiner cites various elements of two Brown embodiments interchangeably, namely, the embodiment of Figures 1-4 of Brown and the very different embodiment of Figure 5 of Brown. Careful analysis of each of the embodiments of Brown independently reveals that Brown does not disclose or suggest the module of the present invention as claimed.

First, with respect to the embodiment of Figures 1-4 of Brown, Brown expressly states that the apparatus comprises a reverse osmosis cartridge 10, comprising spirally wound prefilter 16, reverse osmosis membrane permeator 11, and post-filter 30. The cartridge 10 is installed in housing tube 44. Thus, the prefilter, the reverse osmosis membrane and the post-filter all make up the cartridge 10, which is replaceable in the housing tube 44.

In contrast, claim 1 expressly recites a cylindrical container (corresponding to Brown's housing tube 44) in which are housed, *inter alia*, (1) pretreatment means (corresponding to the Brown prefilter 16), and (2) treatment means. The claim further recites that the treatment means (and thus not the pretreatment means) includes a cartridge including one or more selectively

permeable membranes. Claim 1 further recites that the pretreatment means is housed in the external cylindrical space of the container and the cartridge is housed in the internal cylindrical space of the container. No such cartridge that is independent of pretreatment means is disclosed or suggested in this embodiment of Brown. Indeed, to the extent the Examiner is relying on element 15 of Figure 2 as an impermeable barrier layer that divides the container into two distinct cylindrical spaces, there is no cartridge housed in the internal cylindrical space so defined, as required by the instant claim 1.

The Examiner states that Brown discloses the treatment means being a cartridge, but now removes the citation to Figure 2, element 11 and column 4, lines 6-17 in support of this statement. Presumably the Examiner now agrees with Applicants that element 11 of Figure 2 is a permeator. Column 4, lines 6-17 describe the various layers of this permeator, but never disclose or suggest that it is a cartridge. Indeed, Brown in numerous places indicates that the cartridge includes the combination of the prefilter 16, the reverse osmosis membrane permeator 11, and the post-filter 30. By providing a separate cartridge for the treatment means, the present invention has the advantage of changing that cartridge without also changing the

pretreatment means. This is nowhere disclosed or suggested by Brown.

The Examiner attempts to overcome this deficiency in Brown by dismissing the cartridge claim limitation as not imparting any structural limitation to the claim. This is legally impermissible.

Accordingly, even if one skilled in the art were somehow motivated to completely eliminate the post-filter in either Brown embodiment as the Examiner submits, the present invention as claimed would not be arrived at.

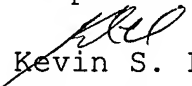
The Examiner maintains the rejection of claims 6, 7 and 18-21 under 35 U.S.C. §103(a) as being unpatentable over Brown in view of Regunathan et al., claims 8, 10-12 and 22 as being unpatentable over Brown in view of Regunathan and further in view of Whittier et al., claims 13-16 as being unpatentable over Brown in view of Regunathan and Whittier and further in view of Burrows, claim 9 as being unpatentable over Brown in view of Regunathan and Whittier and further in view of Petrucci et al., and claim 17 as being unpatentable over Brown in view of Regunathan and Whittier and further in view of Gundrum et al.

These claims are believed to be allowable by virtue of their dependence, for the reasons articulated above with

respect to Brown et al. None of the secondary references supplies the above-noted deficiencies of Brown.

Reconsideration and allowance are respectfully requested in view of the foregoing.

Respectfully submitted,


Kevin S. Lemack

Reg. No. 32,579

176 E. Main Street - Suite 7

Westboro, Massachusetts 01581

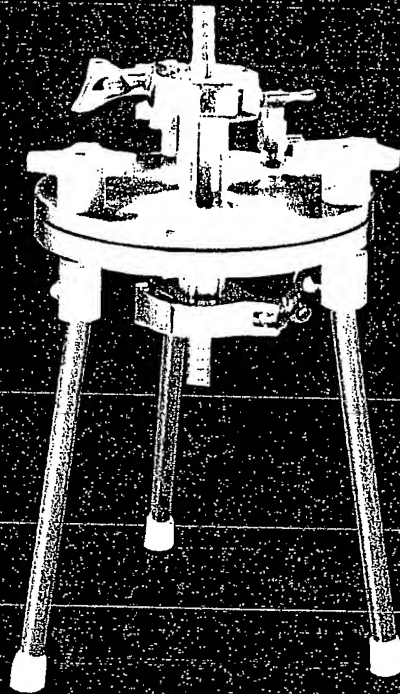
TEL: (508) 898-1818

APPENDIX

An appendix containing Exhibits A, B and C is attached hereto.

Membrane filtration:

*A User's Guide and
Reference Manual*



Thomas D. Brock

Membrane filtration:

A User's Guide and Reference Manual

Thomas D. Brock



A Publication of
SCIENCE TECH, INC. Madison, WI

Thomas D. Brock
Department of Bacteriology
University of Wisconsin-Madison
Madison, WI 53706

Library of Congress Cataloging in Publication Data

Brock, Thomas D.
Membrane filtration.

Bibliography: p.
Includes index.

1. Membrane filters. I. Title. [DNLM: 1. Filtration
—Methods. 2. Membranes, Artificial. 3. Filtration—
Instrumentation. WA 690 B864m]

QD63.F5B76 1983

\$42'.6

82-17027

ISBN 0-910239-00-2

SCIENCE TECH, INC., 1227 Dartmouth Rd.
Madison, WI 53705 USA

Editorial, production, and manufacturing supervision by Katherine M. Brock and Thomas D. Brock. Drawings by Renee Graef. Typeset in ITC Korinna. Printed and bound by Worzalla Publishing Co., Stevens Point, Wisconsin.

All rights reserved. Neither this book nor any of its contents may be translated or reproduced in any form, including electronic and digital means, or placed in any information storage or retrieval system, without the written permission of both the author and publisher.

Copyright ©1983 by Thomas D. Brock
Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

86 85 84 83

alginate salt as a flat sheet, a membrane can be prepared which has suitable filtration properties. The filter lacks mechanical strength, so that it is prepared upon the surface of cellulose filter paper (hence it is a composite membrane).

To produce an aluminum alginate membrane, a filter paper disk is moistened with a solution of 1 molar aluminum chloride. A 1% sodium alginate solution is then spread across the filter paper disk using a square aluminum bar and taking care that a thin, uniform layer is formed. The gel membrane begins to form within 30 seconds and is completed within 90 seconds. After about 30 minutes the filter paper containing the membrane is placed in distilled water. The membrane must be kept moist and can be sterilized by autoclaving. Sterile membranes can be kept for several weeks. The durability of the membrane can be increased and it can be stabilized to desiccation by addition of 1% glycerol to the sodium alginate solution.

The aluminum alginate filter formed by this method can be used in a conventional filter apparatus, and water samples processed in the usual way by vacuum filtration. After filtration, the filter is separated from the paper base, and placed in sterile 3.8% sodium citrate solution. The filter dissolves in this solution within 1–2 minutes without leaving any residue. With this procedure, a dense suspension of particles can be obtained from a very dilute suspension such as a water sample. The filter can be used for concentrating organisms or for obtaining viable counts in water pollution analysis. The formation of aluminum alginate filters is apparently not difficult, and their unique properties may make them attractive for certain kinds of research studies.

Another approach, and one quite historic in its application, is the production of **sintered-particle filters**. Sintering refers to the treatment of a cluster of particles at high temperatures, so that partial fusion of their edges occurs. Pores occur in the interstices between the individual particles, and the pore size can be controlled by the degree of sintering. Sintered porcelain was one of the first types of bacteriological sterilizing filters. Other materials used to make sintered-particle filters are glass and silver. The pore density of sintered-particle filters is low, and filtration rates are hence low, so that these filters are now used primarily where corrosive conditions prevent the use of more conventional membrane filters (see for example Section 14.5).

3.9 Special modifications of membrane filters

Membrane filters may be modified either during or after manufacture, not to alter their permeability properties, but to make them more

useful for certain experimental purposes. In one modification, a dye is used so that the filters are black or green instead of white, making them more useful for certain kinds of particle analyses. In another modification, a hydrophobic rim is added around the edge of the filter, designed to prevent liquid from seeping under the edge of the filter holder and into the part of the filter not involved in the filtration process. Such filters are used in the sterility testing of antibiotic and antiseptic solutions; the toxic material cannot be adsorbed into the outer rim of the filter, and thus is not carried over as an inhibitor onto the culture dish (see Section 7.7). In another special application, grids of hydrophobic material have been printed on the surface of filters, making each square of the grid an independent culture area for a microbiological assay procedure (see Section 9.7). Less complex but of wider utility is the printing of an inked grid on the surface of membrane filters, making counting of colonies on the surface of filters easier. These special types of commercially-available membrane filters are discussed in more detail in subsequent chapters.

A completely solvent-resistant membrane can be made by removing the acetyl groups from the cellulose acetate in already formed membranes, producing **regenerated cellulose membranes**. Deacetylation can be accomplished by treating the cellulose acetate membrane with alkali. The pore structure and physical characteristics of these regenerated cellulose membranes are very nearly identical with the cellulose acetate membranes from which they are derived (Gebott et al., 1970).

In addition to their use as flat filters, membranes may be assembled in cartridges for industrial and other large-scale uses. A cartridge is formed by either pleating or rolling a membrane around a rigid central tube, and then sealing this assembly inside an outer tube of rigid plastic. The ends of the membrane are potted to the top and bottom ends of the cartridge assembly by a suitable adhesive, thus forming an integral unit in which all liquid entering the cartridge must flow through the membrane filter before exiting. We discuss cartridge construction and cartridge filtration in detail in Chapters 6 and 7.

3.10 Summary

This chapter has been devoted primarily to the procedures used for the production of cellulosic membrane filters of graded porosity. The most common materials used in the production of membrane filters are cellulose nitrate and cellulose acetate. These materials form colloidal suspensions (sols) in certain solvents or solvent mixtures. If a thin film of such a sol is spread on a glass surface and subjected to

not necessarily have more capacity than thinner ones. With depth filtration, the filtration characteristics depend more on the nature of the filter material (glass, cellulose, etc.) than on the thickness.

Conventional membrane filters are much thinner than depth filters, but they do have some fibrous character and function at least partially as depth filters. They are available with a wide variety of particle retention capabilities, and in many shapes and sizes. They are certainly the most useful filters for general microfiltration applications. They can be bubble-point tested for integrity.

Nuclepore filters have pores which can be thought of as regularly arranged cylindrical capillaries (see Section 3.6). These filters are closer to true sieves than any other commercially available filters, and are much thinner than conventional membrane filters. They have a lower pore density than microporous filters, show lower fluid flow rates, and clog more easily. They are used primarily in critical filtration processes where the particles must be retained precisely at the surface (for instance, for microscopic study), or where separation of particles by size (sieving) is desired. Although they can be used for conventional membrane filtration, their lower flow rates and higher clogging rates make this generally inadvisable.

The main topic of discussion in this chapter is the microporous membrane filter. Membrane filters are available in two basic configurations, disks and cartridges. Filter disks are available in a wide variety of types and pore sizes, generally in diameters from 13 mm to 293 mm and in pore sizes from 0.1 μm to around 10 μm . The small-sized filter disks are used primarily for analytical work, whereas the larger sizes, capable of filtering volumes of up to 400 liters, are used for process filtration. For really large-volume filtration problems, cartridge configurations are available.

6.5 Cartridge filters

A variety of commercially available filter cartridges are available which permit use of higher pressures and provide much greater filtration area than with disk filters. In general, clogging rate is a function of the area of filter surface exposed to the liquid and thus is much lower with the relatively large surface area of a cartridge filter.

In the formation of a cartridge filter, large sheets of membrane filter material, made pliable by soaking in an agent such as glycerol, are folded in a pleated fashion (Figure 6.1a). Then the pleated membrane is fastened to a central plastic core which has slotted openings. Finally, a protective outer sleeve and end caps are added and the membrane filter is fastened with a resin adhesive (potted) to

the end caps at top and bottom (Figure 6.1b). Some cartridges are constructed with additional pleated support sheets or prefilters inside and outside of the membrane filter, in order to increase reliability and decrease clogging (Figure 6.2).

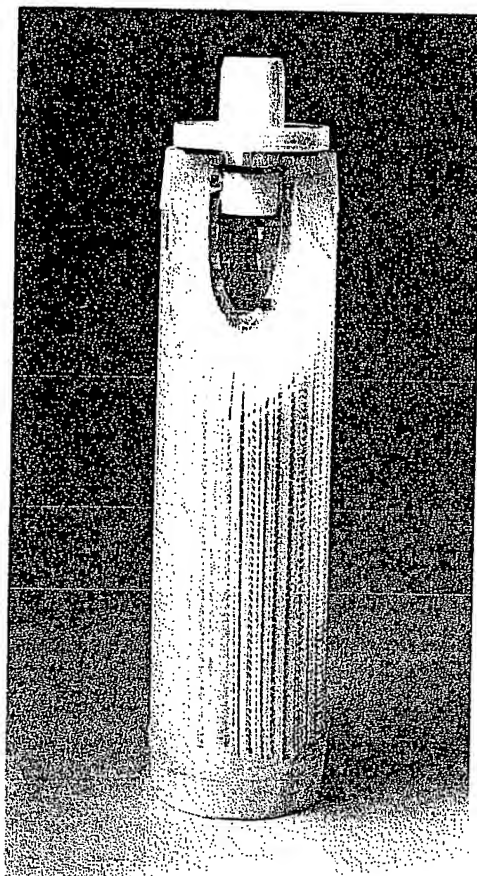
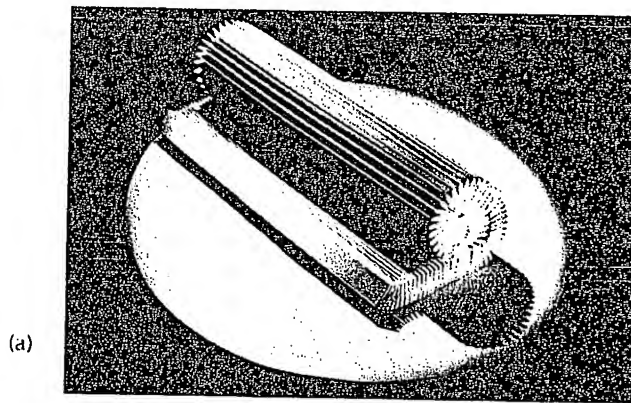
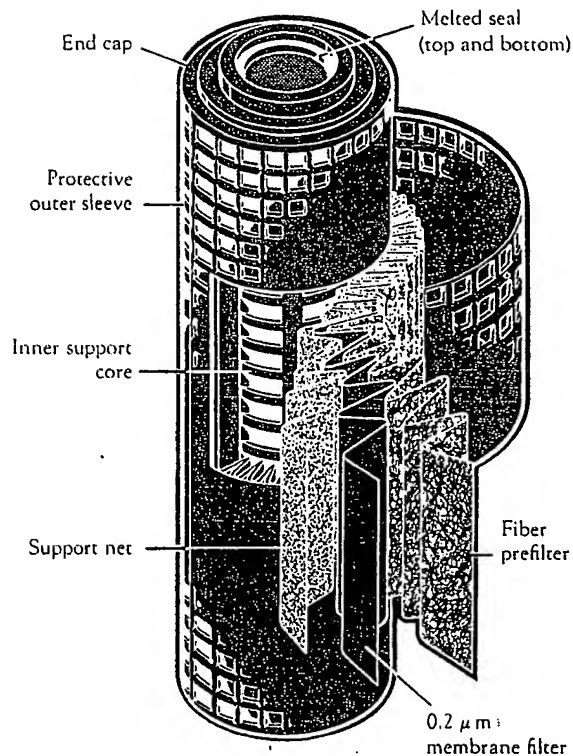


Figure 6.1. a) Pleating membrane filter material as the first step in cartridge formation. b) Cut-away of completed cartridge showing the inner core and outer sleeve, the end caps, and the manner in which the O-ring and housing adapter fit in place. (Photographs courtesy of the Nuclepore Corporation)

Figure 6.2. Drawing of a cartridge filter containing a composite membrane arrangement. (By Membrana, Inc.)



Cartridge filters are recommended for filtering volumes greater than 400 liters. They can be operated at considerably higher pressure differentials than disks. The cartridge is used within a cartridge housing, generally constructed of stainless steel (Figure 6.3a), which is installed in-line in the filtration train. The cartridge is held within the housing by means of gaskets or O-rings. The fluid being filtered flows into the cartridge from the outside, through the pleated filter to the center of the cartridge, and out the opening in the bottom of the unit (Figure 6.3b). Cartridges can be stacked in series or in parallel for greater throughput. The manufacturer's specifications for a cartridge will give the effective filtration area, the pore size, and the operating conditions (temperature, pressure differential, etc.). Pore sizes from 0.2 to 1 μm are available. Filter materials can be cellulose esters, polytetrafluoroethylene (PTFE; Teflon), nylon, or acrylic. Bubble-point testing of cartridge installations is essential to be certain that the cartridge integrity is satisfactory (see Section 4.2 and Section 7.5).

Housings for cartridge filters come in a wide variety of con-

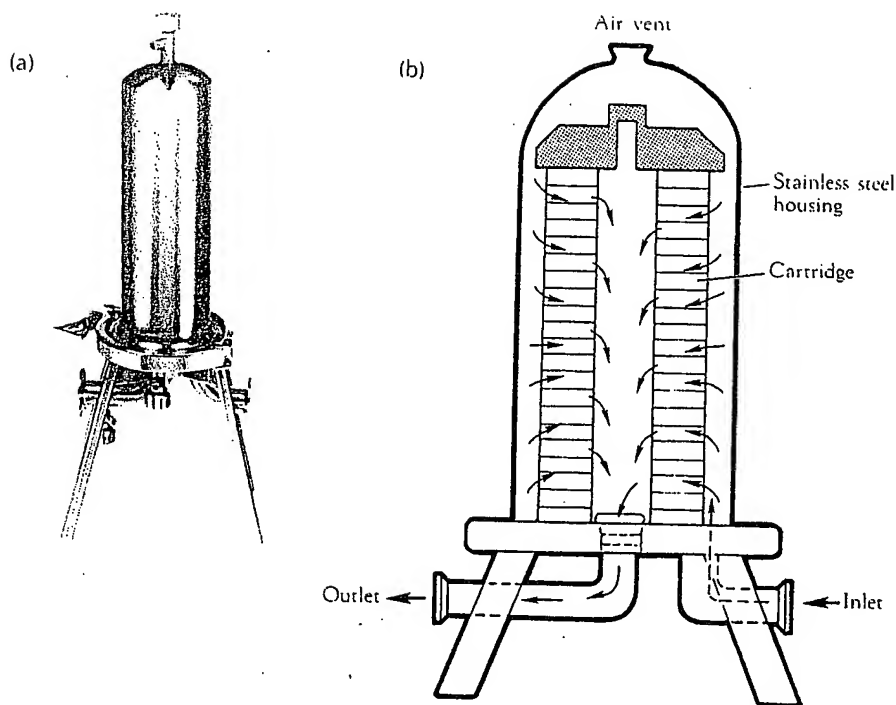


Figure 6.3. Cartridge housing installation. a) Stainless steel housing. b) Cartridge filter unit, showing the arrangement of the cartridge within a stainless steel housing and the pattern of fluid flow through the unit. (Courtesy of Gelman Sciences, Inc.)

figurations. Each cartridge manufacturer has a specific design for end caps of cartridges, so that one cartridge housing may not be suitable for installation of a cartridge from any other manufacturer. However, most cartridge manufacturers also market adapters so that their cartridges can be used with housings of other manufacturers. Since the housing is an expensive purchase, careful selection is recommended. Differences can be found in the design, the materials of construction, and in the seals which hold the cartridge in the housing. Ideally, one should select the cartridge manufacturer first and then purchase the housing supplied by that manufacturer.

Most housings are constructed of 316 stainless steel, an especially noncorrosive metal. The outlets can be either of the industrial or the sanitary type. Industrial type outlets consist of threaded pipe, and connections are made by standard plumbing fittings. Sanitary outlets consist of two flat flanges with a flat gasket between, held together by an outer collar-type clamp (frequently designated T-C, for Tri-Clamp or Tri-Clover, see Figure 6.3a). The advantage of the sanitary outlet is that cleaning is much more effective, as there are

no threads in which particles can collect.

The seal between the cartridge and the housing is especially important, because a faulty seal will permit fluid to bypass the filter completely and enter the filtrate. For cartridge systems rated at $1.0\text{ }\mu\text{m}$ and larger, a simple flat gasket seal fixed upon a knife edge at the end of the cartridge is satisfactory. One disadvantage of this design is that considerable force must be applied to the end of the cartridge to make a good seal against the knife edge; such "end loading" may damage the filter cartridge and the filter inside. To avoid end loading, cartridges rated at less than $1.0\text{ }\mu\text{m}$ use O-rings as seals. The O-rings lie in grooves inside the ends of the cartridge, and are sealed against the cartridge housing by pressure from the side (Figure 6.1c). This "side loading" causes much less strain on the cartridge. The O-ring seal is always used in submicron filtration, such as in cartridge installations used for sterilizing filtration.

Cartridges of various lengths are available (Figure 6.4), thus permitting adjustment of the amount of filter area to the particular filtration task.

Disposable cartridges (called *capsules* by Gelman) are also

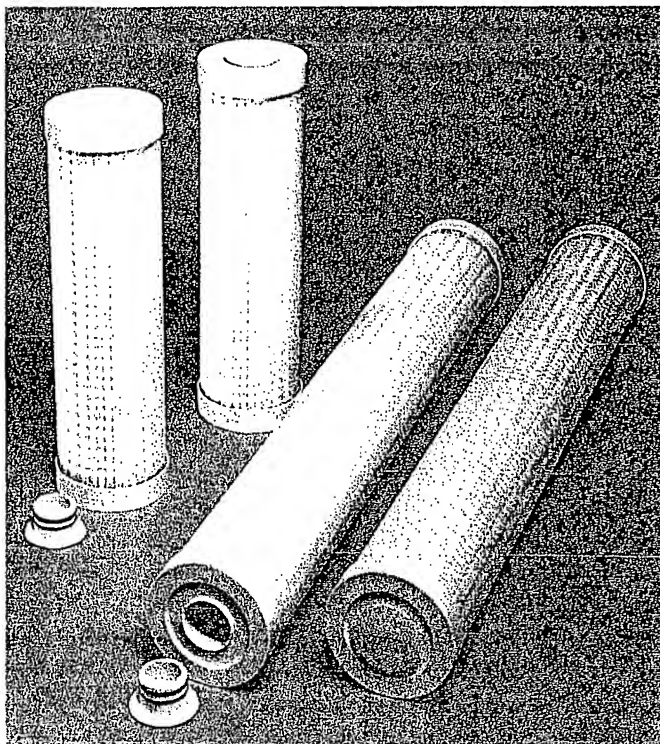


Figure 6.4. Cartridge filters of various lengths. All are 7.4 cm in diameter. (Courtesy of Gelman Sciences, Inc.)

available and are recommended for filtering volumes of 20–600 liters (Figure 6.5). They provide considerably faster flow rates than filter disks, and are more convenient to use than conventional cartridges. They do not require a separate housing, and can be installed in-line in a filtration system. Some can be autoclaved and others are available presterilized. They are available in pore sizes of $0.2\ \mu\text{m}$ for sterile filtration purposes, $0.45\ \mu\text{m}$ for water filtration where absolute sterility is not required, and larger pore sizes for clarification purposes. Because these cartridges are disposable, they are very convenient for moderately large installations.

The advantages of capsule filtration over large-size disk filtration are summarized below:

Large-diameter disk filters	Capsule filters
High capital cost	Economical to use
Danger of cross contamination	Eliminates cross contamination problem
Individual disk filters are not pretested for integrity	Capsules are integrity tested prior to shipment, and are integrity testable by the user
Large space requirements, cumbersome and difficult to handle	Compact in size, and easy to install
Disk filter holders must often be autoclaved prior to use and cleaned between uses	Since capsules are presterile, the need for autoclaving is eliminated, and there are no parts to clean
High operational costs	Maintenance-free
No identification on the individual disk	Each capsule is labeled with a lot number, product number, pore size, and pressure and temperature limitations

The cost difference between disk filters and capsules is not very great. When the cost of the disk filter hardware is included, and the increased labor involved in using disk filters, the capsule is often the more cost-effective alternative. A single capsule has an effective filter area similar to that of a 293 mm disk filter.

Several manufacturers market cartridge filters made not of membranes but of fibers which are wound around a central core. These wound filters are manufactured by Filterite Corporation, Carborundum Corporation, Serfilco Inc., Membrana Inc., and Abcor Inc. By use of fibers of sufficiently small diameter, and by precise winding in a carefully designed pattern, these cartridge filters can be used for removing particles down to less than $1\ \mu\text{m}$. Although not suitable

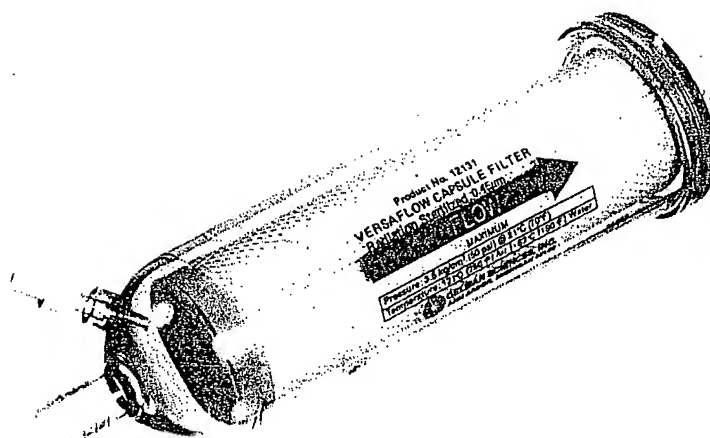


Figure 6.5. A disposable capsule filter of 1480 cm² filter area. (Courtesy of Gelman Sciences, Inc.)

for sterilizing filtration, wound cartridges can be used for clarifying purposes, or for prefiltration of turbid liquids before a sterilizing filtration. Since they function as depth filters, much higher fluid flow rates can be achieved than with membrane filters. Another company which markets fiber cartridges is Balston. The cartridges of this company are not wound, but are composed of glass microfibers bonded with resin to make a depth filter. The smallest particle retention in the Balston filter cartridge is 0.3 μm . Cartridges for ultrafiltration and reverse osmosis are discussed in Chapter 13. A review of cartridge filter construction, manufacture, and evaluation is given by Cole et al. (1979).

6.6 Calculating area of filter needed

For a given flow rate, the area of filter needed for an application must be calculated. One approach is to take the volume of liquid to be filtered and divide by the time available (or desirable) for the process. For the calculation of filter area, a flow rate graph is needed, such as the one in Figure 6.6. This graph relates flow rate to pore size and differential pressure on the system. Most manufacturers give curves such as this for their various filter disks or cartridges. Since the